ATTACHMENT A

FOCUSED FEASIBILITY STUDY

TABLE OF CONTENTS

TABLE OF CONTENTS
Page 2

FOCUSED FEASIBILITY STUDY FOR NORTHWEST AGGREGATES GRAVEL MINE

1.0 INTRODUCTION

This report presents a focused Feasibility Study (FS) for Northwest Aggregates (NWA) Gravel Mine located on Maury Island in Washington. This FS is identified as "focused" because it is focused on remedial alternatives for soil contaminated with arsenic. This FS is based on site characterization data provided in the Mitigation Report for Contaminated Soil (MRCS) to which this FS is attached. The objective of this FS is to develop and evaluate remedial action alternatives for the site.

1.1 Report Organization

This FS report is organized as follows:

Section 1.0 Describes the objective of the FS, the report organization, and the NWA site.

Section 2.0 Identifies and screens preliminary remedial alternatives for this site.

Section 3.0 Describes the MTCA cleanup standards as they apply to the NWA site.

Section 4.0 Presents a detailed analysis of the final alternatives selected in Section 2.0.

Section 5.0 Summarizes the preferred remedial alternative selected for the NWA site.

Section 6.0 Provides a list of cited references.

1.2 Site Characterization

NWA operates a sand and gravel mine on the SE end of Maury Island, which is north of Tacoma and connected to and east of Vashon Island in the Puget Sound Region. Sand and gravel mining activities have been conducted at this site since the 1940s, and by NWA (or their predecessors) since the late 1960s. Mining activity on the site is currently conducted under a Grading Permit from King County (Permit No. 1128-714, April 1997) and a Surface Mining Reclamation Permit from the Washington State Department of Natural Resources (Permit No. 70-010256, 1971). Current operations are also covered by a Determination of Non-Significance issued by King County in 1977. These approvals permit mining, processing, reclamation, and shipping and barge activity on approximately 193 acres of the 235-acre site. Of these 193 acres, approximately 40 acres of the site have been previously mined, and approximately 9 acres used for active mining.

King County is currently conducting a periodic review of the site's development and operating standards pursuant to King County Code 21A.22.050. In addition, NWA is proposing to revise and upgrade the existing Surface Mining Reclamation Permit to comply with the 1993 amendments to the State's Surface Mining Act RCW Chapter 78.44 by revising the existing Grading Permit. In support of these re-permitting activities, samples have been collected at NWA site since to evaluate current conditions. Soil impacts were identified; however, groundwater was not determined to be impacted at levels requiring implementation of a cleanup action. For this reason, groundwater remediation is not evaluated in this FS.

Site characterization activities indicate that the contaminants of concern in soils at the site are lead, arsenic, and cadmium and that the vertical extent of contamination is generally limited to the uppermost one-and-one-half to two feet of topsoil. Contamination is highest at the surface and decreases with depth. The areal extent of contaminated soil is shown in Figures 4, 5, 6, and 7 of the MRSC.

Arsenic is the principal contaminant of concern at the NWA site and it is estimated that approximately 271,000 cubic yards of soil are contaminated with arsenic over 20 parts per million (ppm). Of this total, approximately 50,520 cubic yards of soil are estimated to be above 200 ppm of arsenic. Arsenic chemistry is very complex. Arsenic is a nonmetal or metalloid, although it is often referred to as a metal in the environmental field (and in this FS). Arsenic present in soils at the NWA site is due to airborne fallout from smelting operations at the former ASARCO smelter in Tacoma. ASARCO conducted nonferrous smelting operations at this location. Flue dusts from nonferrous smelting operations are known to produce arsenic in the form As_2O_3, arsenic trioxide (Conner 1990). The oxide is amphoteric and is soluble in both acids and bases.

2.0 IDENTIFICATION AND SCREENING OF PRELIMINARY ALTERNATIVES

Comprehensive lists of remedial technologies are presented in a number of reference documents published by the United States Environmental Protection Agency (EPA), based on work conducted for Superfund sites under the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) program. These reference documents were reviewed in conjunction with available literature on current, innovative technologies to select preliminary remedial alternatives potentially applicable to the NWA Gravel Mine site. The following six technologies were selected to be potentially applicable based on the type of contaminants present at the site (arsenic, lead, and cadmium):

1) Excavation and off-site disposal
2) Soil-cement stabilization
3) KEECO treatment
4) On-site containment in cells
5) In-situ capping
6) In-situ stabilization

These technologies were initially screened based on implementability, which is a CERCLA criterion for the evaluation of remedial alternatives (USEPA 1988). Implementability is defined as a general measure of whether a given technology could be effectively implemented at the site. Because the site is to be used as a sand and gravel mine, *in situ* processes are not appropriate because contaminated overburden soil must be removed to access the sand and gravel. Therefore, *in situ* processes were eliminated from further consideration and the final remedial alternatives selected for detailed analysis in Section 3.0 include:

1) Excavation and off-site disposal
2) Soil-cement stabilization
3) KEECO treatment

4) On-site containment in cells

These final alternatives encompass a range of remedial action options including: an alternative that requires no long term on-site management of residuals, an alternative that immobilizes contaminants using solidification/stabilization, an alternative that utilizes treatment as a principal element, and an alternative that prevents movement of contaminants without treatment.

3.0 MTCA CLEANUP STANDARDS

The process for selecting a cleanup action is described in WAC 173-340-360. In adherence with the Model Toxics Control Act (MTCA) Cleanup Regulation (Chapter 173-340 WAC), a cleanup action must comply with MTCA cleanup standards (RCW 70.105D.030(2)(d)). To establish cleanup standards the following must be specified:

- MTCA cleanup levels,
- Points of compliance (POCs), and
- Applicable state and federal laws.

Each element of MTCA cleanup standards is discussed in the following sections.

3.1 MTCA Cleanup Levels

MTCA cleanup levels are concentrations of hazardous substances that have been determined to be protective of human health and the environment under specific exposure conditions. Ecology has developed three methods for determining cleanup levels under MTCA: Method A, Method B, and Method C. Method A is applicable to sites with routine cleanup actions and/or for sites with hazardous substances that are all listed in Method A tables. Method A may be used for residential properties or for industrial properties that meet specific qualifying criteria provided in WAC 173-340-745. Method B is applicable to all sites.

Method C is used when the cleanup levels under Method A or B cannot be achieved, are lower than background concentrations, or when achieving Method A or B cleanup levels may cause more environmental damage. Method C is also used for industrial properties that meet the MTCA qualifying criteria (WAC 173-340-745).

In an effort to provide the citizen's of Maury Island with the maximum protection, NWA has selected MTCA Method A cleanup levels for residential soils (MTCA Method A residential cleanup levels). A comprehensive list of cleanup levels for the NWA site is provided in Table 6 of the MRCS report.

Based on a comparison of site arsenic concentrations with Method A residential cleanup levels, it is estimated that up to 271,000 cubic yards of soil is contaminated with arsenic. NWA plans to remediate contaminated soil in six phases consistent with mining activities at the site, using the preferred remedial alternative selected in Section 5.0 of this FS. NWA plans to expose approximately 30 acres at a time for mining with no more than 60 acres exposed at any time. The volume of material that will be remediated during each mining phase is summarized in Table 1 below for residential and industrial Method A cleanup levels.

Table 1: Estimated Volume of Contaminated Soil per Operating Phase at NWA Gravel Mine.

Operating Phase	Estimated Volume of Contaminated Soil	
	MTCA Method A Cleanup Levels for Residential Soils	MTCA Method A Cleanup Levels for Industrial Soils
1	6,100	3,438
2	40,300	9,444
3	60,700	11,944
4	49,900	20,139
5	84,300	5,555
6	29,500	0
TOTAL	**271,000**	**50,520**

3.2 Points of Compliance (POCs)

POCs designate the locations on site where cleanup levels must be met. For soil, POCs based on the protection of groundwater are located in soils throughout the site (WAC 173-340-740(6)(b)). POCs based on the protection of human health via direct contact are located in soils throughout the site from ground surface to a depth of 15 feet below ground surface (WAC 173-340-740(6)(c)).

3.3 Applicable State and Federal Laws

Additional regulatory requirements (applicable state and federal laws) may also apply to a cleanup action because of the type of action and/or the location of the site (WAC 173-340-200). Typically, these additional regulatory requirements are established following the selection of the cleanup action for the site.

4.0 IDENTIFICATION AND SCREENING OF FINAL ALTERNATIVES

The initial screening determined that four final alternatives are potentially applicable to the NWA site based on the type of contaminants present in soils (primarily arsenic and lead) and the limitations necessary to continue operation of the site as a sand and gravel mine. These four alternatives include: excavation and off-site disposal, soil-cement stabilization, KEECO treatment, and on-site containment in cells.

Each of these final remedial alternatives were evaluated against the following detailed MTCA evaluation criteria (WAC 173-340-360(2) and (3)):

- Overall Protection of Human Health and the Environment
- Compliance with Cleanup Standards
- Use of Permanent Solutions to the Maximum Extent Practicable
- Compliance with Applicable State and Federal Laws
- Provision for Compliance Monitoring
- Provision for Reasonable Restoration Time Frame

The final alternatives were also evaluated against the following three criteria, listed in order of importance:

- Effectiveness
- Implementability
- Cost

These criteria are specified in MTCA (under other requirements WAC 173-340-360(3)) and in CERCLA (USEPA 1988).

The purpose of this evaluation is to select a preferred remedial alternative for addressing the contaminated soil areas of the NWA Gravel Mine site that ensures the protection of human health and the environment. Detailed evaluations of the final candidate alternatives are presented in the following sections.

4.1 Excavation and Off-Site Disposal

This alternative includes excavation of contaminated topsoil and off-site disposal at an Upland Regional (RCRA Subtitle D) Landfill. As discussed in Section 3.1, NWA plans to remove the contaminated soil in phases consistent with mining activities at the site. The total volume of contaminated soils will depend on the results of ongoing confirmation testing. For the purpose of comparison for the FS, this remedy was evaluated for an estimated total contaminated volume of 271,000 cubic yards.

4.1.1 Application

An excavation and disposal plan was developed and is described in this section. This plan is based on using NWA facilities and leased equipment for the excavation, material transport, and unloading operations.

NWA has an onsite conveyor and loading dock that could be used to load 2,000-ton flat deck haul barges. A drive-over feed hopper facility would be constructed at the end of the existing conveyor. A Cat 613, 11-cubic-yard, self-propelled, rubber-tired scraper would excavate the topsoil and haul it to the feed hopper where it would be discharged onto the conveyor belt. The belt would load the barge with about 1,500 tons of soil. The haul barge would be towed by a 800 HP tug approximately 26 miles to NWA's aggregate plant on the west bank of the East Duwamish Waterway in Seattle.

At the Duwamish aggregate plant, a Cat 966, 4.5-cubic-yard, front-end loader working off the barge would load the material onto NWA's onsite aggregate conveyor. The material would be discharged into the Regional Disposal Site operator's hauling vehicles. The material would then be transported to the disposal site operator's rail transfer facility (on Lander Street or Alaska Street, depending on the disposal site operator used). At the rail transfer facility, the material would be loaded into gondola rail cars and delivered to either Rabanco's Roosevelt Landfill near

Goldendale, WA or Waste Management USA's Columbia Ridge Landfill near Arlington, OR. These facilities are located near the Columbia River about 250 highway miles from Seattle.

4.1.2 Compliance with MTCA Criteria

4.1.2.1 Overall Protection of Human Health and the Environment

This remedy would be protective of human health and the environment since the contaminated soil would be excavated and removed from the site. However, increased handling and transport of contaminated soil are required for this alternative relative to other alternatives.

4.1.2.2 Compliance with Cleanup Standards

Excavation and off-site disposal will comply with MTCA cleanup standards.

4.1.2.3 Use of Permanent Solutions to the Maximum Extent Practicable

Excavation and off-site disposal is a reliable remedial technology. Under Ecology's MTCA rules, a cleanup action involving off-site transport and disposal of hazardous substances without treatment shall not be used if an alternate treatment method exists and is practicable (WAC 173-340-360(5)(e)(v).

4.1.2.4 Compliance with Applicable State and Federal Laws

The excavation and off-site disposal remedy will comply with MTCA cleanup standards (WAC 173-340-700 through –760), including applicable state and federal laws (WAC 173-340-710). All applicable state and federal laws will be determined upon selection of the preferred remedial alternative.

4.1.2.5 Provision for Compliance Monitoring

Compliance monitoring is an element of all the remedies considered in this FS. This program will be developed in the Compliance Monitoring Plan for the site.

4.1.2.6 Provision for Reasonable Restoration Time Frame

This remedy constitutes an expedient removal of contaminants. The estimated time frame necessary to achieve completion of the project would be provided following detailed design of this remedial alternative.

4.1.2.7 Effectiveness

This technology is effective in removing the contamination from the site thereby protecting human health and the environment on Maury Island.

4.1.2.8 Implementability

Although this remedy is simple, it requires increased handling and transport (across water) of contaminated soil relative to other alternatives. Due to the increased handling and transport, this technology is difficult to implement in a cost-effective manner.

4.1.2.9 Cost

The estimated cost for excavation, transportation, and disposal at an Upland Regional Landfill is high relative to the other alternatives. This relatively high cost is due to the increased handling and transport.

4.2 Soil-Cement Stabilization

Soil-cement is a solidification/stabilization (S/S) technology. S/S technology is effective in immobilizing most inorganic contaminants. Stabilization is generally described as a chemical reaction that converts a contaminant to a form that has reduced solubility, toxicity, and mobility. Typically, stabilization does not alter the physical structure of the waste. Solidification is a process by which contaminants are encapsulated in a monolithic structure or soil-like material of high structural integrity. Solidification mechanically binds the waste, but does not necessarily involve a chemical interaction between the waste and the binder(s).

4.2.1 Application

Soil-cement is a remedial technology that immobilizes contaminants by mixing contaminated soil with a binder (or mixture of binders) and curing the mixture to form a solid matrix. Additives may also be used, if deemed appropriate. The soil-cement process typically involves six steps:

1. excavation,
2. size segregation,
3. reduction of oversized particles,
4. addition of binding reagent(s) and additives,
5. mixing of contaminated soil and debris with binding reagent(s) and additives, and
6. beneficial reuse of treated soil (e.g., as a sub base for pavement) or disposal.

Inorganic cementitious S/S processes utilize various combinations of binders and typically result in very stable products. Common binders include Portland cement, fly ash, cement kiln dust, quick lime, and slags. Portland cement is inexpensive and the most widely used binder for this application. It is a hydraulic cement that produces a hardened paste upon addition of water through several chemical reactions. The presence of calcium hydroxide and alkalis in solution result in a cement paste with a high pH (alkaline). An understanding of this condition is important in successfully applying cement-based S/S technologies (Suthersan 1997).

Blast furnace slag (a blend of amorphous silicates and aluminosilicates of calcium and other bases) may act as a reducing agent for metal species that are less mobile in a reduced valence state, due to the presence of ferrous iron and reduced sulfur compounds (Suthersan 1997). Portland cement combined with slag is commonly used in stabilizing heavy metal contamination. As an added benefit, the addition of slag may enhance settling and compaction of the waste material.

4.2.2 Compliance with MTCA Criteria

4.2.2.1 Overall Protection of Human Health and the Environment

Application of the soil-cement remedial action is designed to be protective of both human health and the environment. This S/S technology is expected to reduce the solubility, toxicity, and mobility of contaminants and immobilize the contaminated soil in a soil-like matrix of high structural integrity. It is also anticipated that the resulting matrix will prevent leaching to the groundwater at levels that would cause adverse effects to human health and the environment. However, treatability studies would be required to verify sufficient stabilization of arsenic could be attained prior to using this technology.

4.2.2.2 Compliance with Cleanup Standards

Effective application of this technology is expected to comply with MTCA cleanup standards. However, arsenic chemistry is very complex (e.g., pH sensitivities) and difficulties were identified for stabilizing metals (see Section 4.2.2.7). Given these issues, matrix-specific treatability studies would be necessary to ensure effective compliance with MTCA cleanup standards.

4.2.2.3 Use of Permanent Solutions to the Maximum Extent Practicable

This remedy provides for a permanent solution. Soil-cement is expected to be durable for centuries if adequate amounts of cement are used and the material is properly cured. Soil-cement provides a permanent reduction of toxicity and mobility (WAC 173-340-360(5)(c)).

4.2.2.4 Compliance with Applicable State and Federal Laws

It is expected that the soil-cement remedy will comply with MTCA cleanup standards (WAC 173-340-700 through –760), including applicable state and federal laws (WAC 173-340-710). All applicable state and federal laws will be determined upon selection of the preferred remedial alternative.

4.2.2.5 Provision for Compliance Monitoring

Compliance monitoring is an element of all the remedies considered in this FS. This program will be developed in the Compliance Monitoring Plan for the site.

4.2.2.6 Provision for Reasonable Restoration Time Frame

This remedy provides a reasonable restoration time frame. The estimated time frame necessary to achieve completion of the project will be provided following detailed design of the preferred remedial alternative.

4.2.2.7 Effectiveness

S/S technology is considered to be a proven treatment technology by the EPA and has been selected for remediating over 30 percent of EPA's Superfund sites (Adaska et al. 1991). To ensure the effectiveness of this technology for contaminants at the NWA site, treatability studies would be necessary prior to full-scale application. The studies would be used to select effective binders and to determine the required addition rate. The following soil parameters may be collected, in part to determine the effectiveness of soil-cement, during treatability studies and again during site remediation, if necessary (Van Deuren et al. 1997):

- pH
- Particle size
- Atterberg limits
- Moisture content
- Metal concentrations
- Sulfate content
- Organic content
- Density
- Permeability
- Unconfined compressive strength
- Leachability
- Microstructure analysis
- Physical and chemical durability

To accurately assess limitations of soil-cement technology, it is necessary to consider the chemistry of the contaminants and the potential interactions between the waste, binders, and any interfering chemicals. Arsenic is the primary inorganic contaminant of concern at the NWA site. Gilliam and Wiles (1992) state: "Arsenic under oxidizing conditions will be in the pentavalent form and will be soluble over a broad range of pH values (pH from ~2 to 14). Thus, in order to stabilize arsenic chemically, it may be necessary to reduce it to the trivalent or elemental form. In this case, the pH must be maintained below 11, as As(III) becomes soluble at a pH of >11." Conversely, as described earlier, Wilk (1997) notes that it is beneficial to oxidize arsenic to the higher oxidation state (arsenate) before stabilization. Both sources are in agreement that a condition where the pH is maintained at a value less than 11 is preferable for decreasing the solubility of As(III); however, they do not agree on the form of arsenic that is optimal. It is important to note that the pH value that is optimal for decreasing arsenic solubility may mobilize lead and could affect setting of the soil-cement matrix. For this reason, wastes containing arsenic and lead must be treated with a S/S process that has been carefully designed using matrix-specific treatability studies.

4.2.2.8 Implementability

Soil-cement is a type of S/S technology that has been proven to be very reliable in remediating soils contaminated with metals. However, stabilization of metals may be difficult due to complexation and variable oxidation states. Further, arsenic is generally more difficult to stabilize than other metals. Successful implementation of S/S technology for metals should include the following (Adaska et al. 1991):

- Control of excess acidity by neutralization;
- Destruction of metal complexes if necessary;
- Control of oxidation state as needed;
- Conversion of insoluble species (stabilization); and
- Formation of a solid or solid-like material with solidification reagents.

One potential drawback of this technology is the significant increase in volume (typically two times the original volume). This may lead to on-site disposal concerns.

4.2.2.9 Cost

The cost for application of *ex situ* soil-cement technology depends on several factors including the type of binder (cement) used and whether or not additives are used. Cost estimates for this technology are extremely high and may not be proportional to the degree of protection that will be achieved.

4.3 KEECO Treatment

Klean Earth Environmental Company (KEECO) has been in business since 1993 and is located in Lynnwood, Washington. This company manufactures proprietary chemicals, which target metals immobilization. KEECO stabilization treatment consists of a simple on-site treatment of metals -contaminated soil above regulatory limits using silica microencapsulation (SME). In application of this process to the NWA site, excavated soil will be mixed with a small amount of water (if needed) and a proprietary chemical, KB-SEA™, in a pug mill or ribbon blender. The proprietary chemical utilizes a combination precipitation, flocculation, and chemisorption mechanism that results in permanent encapsulation of heavy metals in a silica matrix. KB-SEA™ is formulated to react slowly in the soil medium to compensate for reduced mass transfer rates. The complete encapsulation reaction typically takes 24 to 48 hours. Soil pH rises as the reaction occurs and then drops slowly to neutral.

Upon successful treatment contaminant metals are stabilized in an inert form in the soil that will not leach to groundwater. The treated soil may remain on-site and be reused and handled as if uncontaminated by metals. Volume of the contaminated soil will be unaffected by this treatment process.

4.3.1 Application

The arsenic-contaminated soil to be stabilized would be mixed in a pug mill or ribbon blender with about 1 to 5% of the SME chemical and approximately 5 to 10% water. The water promotes the reaction of the silica encapsulation chemical with metals in the soil. Added water may not be needed if soil moisture is sufficient. The encapsulation reaction requires a small amount of time to complete, hence, treated soil would not be considered fully remediated for approximately 24 to 48 hours after completion.

The reaction temporarily increases pH moderately, depending on the amount of treatment chemical needed. After reaction completion pH slowly returns to neutral. It is not known if this change in pH would be sufficient to solubilize some arsenic. If so, it would be necessary to isolate treated soil until pH drops sufficiently. After reaction completion it is expected that the stabilized soil may be handled as if uncontaminated with respect to metals.

4.3.2 Compliance with MTCA Criteria

4.3.2.1 Overall Protection of Human Health and the Environment

If the SME technology works as anticipated, overall protection of human health would be expected. Once the heavy metals are stabilized, they will be unavailable for transport into the environment and, hence, unavailable for human uptake. The final product is a dense, sand-like material that is unlikely to be ingested or inhaled. Application of SME will reduce the mobility of heavy metals to move freely through the environment. The metals will still exist in the environment but will be in an inert form, thus, reducing toxicity.

4.3.2.2 Compliance with Cleanup Standards

It is expected that KEECO treatment will comply with MTCA cleanup standards. However, as with soil stabilization, treatability studies would be required.

4.3.2.3 Use of Permanent Solutions to the Maximum Extent Practicable

Encapsulated metals on the soil will be made inert.

4.3.2.4 Compliance with Applicable State and Federal Laws

Successful stabilization will assure compliance with MTCA cleanup standards (WAC 173-340-700 through –760), including applicable state and federal laws (WAC 173-340-710). All applicable state and federal laws will be determined upon selection of the preferred remedial alternative.

4.3.2.5 Provision for Compliance Monitoring

Compliance monitoring is an element of all the remedies considered in this FS. This program will be developed in the Compliance Monitoring Plan for the site.

4.3.2.6 Provision for Reasonable Restoration Time Frame

This remedy constitutes an expedient removal of contaminants. The estimated time frame necessary to achieve completion of the project will be provided following detailed design of the preferred remedial alternative.

4.3.2.7 Effectiveness

Stabilization by SME can provide both short-term and long-term effectiveness. Metals are isolated and will not leach to the environment due to the inertness of the encapsulating media. Because this is an innovative technology, pilot-scale trials on representative site soils would be necessary verify effectiveness of the technique before full-scale application. The goals of the trials would be to optimize the additive level, required moisture, and mixing technique. Sampling of feed and product soils for metals and by TCLP would also be required to demonstrate effectiveness.

4.3.2.8 Implementability

The most critical factor to the feasibility of SME will be its implementability. The technology must be proven in trials to be capable of rendering the metal contamination inert. Although SME has been applied successfully in similar situations, testing and data generation must be done to verify its applicability to the NWA Gravel Mine. Such testing must be done to determine the optimal operational implementation of the SME technology as well as to produce a final soil sample that successfully satisfies TCLP requirements.

Successful application of this technology would allow reuse of the treated soil to revegetate mined areas, instead of importing clean fill.

4.3.2.9 Cost

Total costs including purchase of chemicals, screening of soil, the pug mill or ribbon blender, water, and soil handling can only be estimated.

4.4 On-Site Containment in Lined Cells

On-site containment in lined cells consists of placing overburden soil contaminated with metals into a containment cell on the NWA site. The primary purpose of the containment cell is to provide protection of the groundwater from possible contamination for arsenic leaching from the contaminated soil. For this remedy, soil would be consolidated on-site in a containment cell. The cell would have a low-permeability cover and liner to prevent rainwater infiltration into the cell and to prevent potential leachate from seeping to the ground.

The total volume that is contaminated with arsenic above MTCA Method A residential cleanup levels is estimated to be 271,000 cubic yards. Of this total volume, approximately 50,520 cubic yards contains arsenic concentrations above MTCA Method A industrial cleanup levels. Soils contaminated above MTCA Method A industrial cleanup levels will be managed in a separate containment cell. This cell will be provided with more stringent institutional controls providing greater protection to human health and the environment.

4.4.1 Application

The containment cell would be built along the north side of the property in phases. The location is shown on Figure 1. Construction would start on the downslope side (north) and proceed to the south. A typical cross-section in the north-south direction is shown on Figure 2 and a typical profile in the east-west direction is shown on Figure 3.

The first step would be to prepare the site subgrade. The natural ground surface slopes up from north to south at about 10 to 12 percent. After clearing and grubbing, the subgrade would follow the existing slope, except that benches with a slope of 2 to 4 percent (down toward north) would be excavated. The purposes of the benches are to provide a stable fill and to allow fill placement and compaction of near-level surfaces.

A bottom liner is not required for inert and demolition waste per WAC 173-304-461. A TCLP test was conducted on soils with a total arsenic concentration of greater than 100 milligrams per kilogram (mg/kg). Although the extracted arsenic concentrations are well below the dangerous waste level of 5,000 micrograms per liter (ug/l) (or 5 milligrams per liter [mg/l]), concentrations in several samples were above the MTCA Method A level for groundwater of 5 ug/l. Therefore, it is prudent to place a low-permeability liner and cover in the containment cell.

The liner requirement for solid waste landfills of all types is specified in WAC 173-304-460. The functional design is four feet of clay with 1×10^{-7} cm/sec permeability; or a geosynthetic membrane and two feet of clay with 1×10^{-6} cm/sec permeability, or equivalent system. The liner requirements for a limited purpose landfill are determined on a case-by-case basis.

The contaminated soil placed into the containment cell will not be a source of leachate. The soil is predominately inorganic and will not decompose and generate leachate like household refuse. The volume of rainwater infiltration will be less than an operating refuse landfill because the containment cell will be constructed in discrete phases, as compared to continuous daily operation of refuse landfills. Therefore, a single layer of geosynthetic clay liner (GCL) is proposed for the liner. GCLs are made with a layer of refined clay with permeabilities of 1×10^{-8} to 10^{-9} cm/sec bound between layers of geotextile. A GCL is considered equivalent to two to four feet of clay with 1×10^{-7} cm/sec. GCL is recommended over one layer of geosynthetic membrane because defects in membranes or membrane seams can result in leakage. The clay in GCLs will swell as it is exposed to water and this swelling action closes possible openings in the liner.

A GCL liner needs to be protected from damage during installation and construction. A layer of bedding sand 6 inches thick will be placed over the subgrade to protect the liner from puncture by the gravelly soil. The bedding sand should be screened to remove all material larger than ½ inch. The GCL would be covered with a 6-inch layer of drain sand. The drain sand should consist of material with 100 percent finer than ½ inch and less than 3 percent finer than the U.S. No. 200 sieve (0.003 inches). An alternative to the drain sand would be to place a synthetic drainage net composite with geotextile on two sides.

An internal drainage system of piping would not be needed. A 6-inch diameter perforated pipe would be installed along the north (downslope) side of the cell. This drain would lead to a manhole on one end of the cell. The purposes of this drain are to prevent build-up of water over the liner and to provide a sampling location. A 2-inch diameter perforated pipe would be installed in the bedding sand (under the liner) along the north side. This would also lead to a manhole on one end of the cell and could be used to monitor water under the liner.

The contaminated soil would be placed over the drain sand. The soil should be placed in horizontal layers and compacted to 90 percent density. The purpose of placement and compaction is to provide a stable slope and firm support for the final cover. It is assumed that trees and brush will be removed from contaminated areas prior to excavation of contaminated soil. The trees and brush should not be placed into the containment cell. It is expected that the contaminated soil will contain some natural organic materials such as roots and vegetation.

The cover system should provide the same barrier to infiltration as the liner. A single layer of synthetic membrane or GCL is proposed for the cover. The base for the membrane must be screened soil with 100 percent finer than ½ inch. The base sand could be contaminated soil that has been screened. A flexible membrane would be suitable for the cover because a cover is less susceptible to physical damage than the liner. A flexible membrane would be covered with a geotextile fabric to protect it from damage. The cover would be covered with a 6-inch layer of screened drain sand or synthetic drain layer, the same as used over the liner. The drain layer would be covered with 18 inches of soil, then the surface would be vegetated. Topsoil would not be required as long as the cover soil has sufficient nutrients to support a healthy vegetation cover. The vegetation is needed to prevent surface erosion and for aesthetics.

The containment cell would be constructed in steps to match mine operation. The first step would start at the downslope (north) end, to collect rainwater infiltration and potential leachate. The first step would probably have the capacity to take soil from Phase 1 and 2 of the mine operation (or about 46,000 cubic yards of contaminated soil). During soil placement, temporary berms would be constructed upslope to divert rainfall runoff from entering the cells. Some rainfall runoff would seep into the sand drain layer over the GCL during soil placement. This water would drain into the perforated pipe at the downslope side.

Stability of the GCL or geomembrane cover is an important design and construction issue. Placement of covers on the perimeter slope of 3 horizontal to 1 vertical has been done, but requires careful design and construction methods for stability.

4.4.2 Compliance with MTCA Criteria

4.4.2.1 Overall Protection of Human Health and the Environment

Containment would be protective of human health and the environment. This alternative would have no long-term environmental impacts and minimum short-term impacts. There is a potential for dust generation during earthwork, but this can be controlled with conventional dust control methods.

4.4.2.2 Compliance with Cleanup Standards

It is expected that on-site containment in lined cells will comply with MTCA cleanup standards.

4.4.2.3 Use of Permanent Solutions to the Maximum Extent Practicable

On-site containment in lined cells is a reliable remedial technology. However, MTCA does not consider containment of hazardous substances to be a permanent solution (WAC 173-340-360(5)(c)). For this site lined containment cells are considered to be "bulk stabilization."

4.4.2.4 Compliance with Applicable State and Federal Laws

It is expected that on-site containment in lined cells will comply with MTCA cleanup standards and all applicable state and federal laws (WAC 173-340-710). A more detailed evaluation of applicable state and federal laws will be conducted upon selection of the preferred remedial alternative.

4.4.2.5 Provision for Compliance Monitoring

Compliance monitoring is an element of all the remedies considered in this FS. This program will be developed in the Compliance Monitoring Plan for the site.

4.4.2.6 Provision for Reasonable Restoration Time Frame

This remedy constitutes expedient containment of the contaminated soil on site. The estimated time frame necessary to achieve completion of the project will be provided following detailed design of the preferred remedial alternative.

4.4.2.7 Effectiveness

Containment cell design and construction is a proven technology that has been effectively implemented on numerous other sites.

4.4.2.8 Implementability

This remedy is easily implemented. The containment cell would be constructed with conventional earthwork equipment and standard earthwork construction methods.

4.4.2.9 Cost

The costs for the on-site containment alternative result primarily from material handling and cover and liner materials. Costs for this alternative are expected to be reasonable.

5.0 SELECTION OF THE PREFERRED REMEDAL ALTERNATIVE

The detailed evaluation presented in Section 4.0 was used to select a preferred remedial alternative. The evaluation is summarized for each alternative in Table 7, which presents a ranking of the remedial action technologies by the MTCA criteria. To quantify the analysis, a relative score of 0, 1, 2, or 3 (corresponding to no, low, medium, and high) was assigned for compliance with each criterion. This allows an objective means for ranking the alternatives.

Table 2: Ranking of the Alternatives by MTCA Criteria.

ALTERNATIVE	Excavation and Off-site Disposal	Soil-cement Stabilization	KEECO Treatment	On-site Containment in Lined Cells
Overall Protection of Human Health and the Environment	2	2	3	3

Compliance with Cleanup Standards	3	3	3	3
Use of Permanent Solutions	0	3	3	1
Compliance with Applicable State and Federal Laws	3	3	3	3
Provision for Compliance Monitoring	3	3	3	3
Provision for Reasonable Restoration Time Frame	3	3	3	3
Effectiveness	3	2*	1*	3
Implementability	2	2	1	3
Cost	1	1	2	3
Total	**20**	**22**	**22**	**25**

*treatability studies required to verify effectiveness

Based on the criteria evaluation in Table 2, on-site containment in lined cells is the preferred remedial alternative for the NWA gravel mine site. Soil-cement stabilization and KEECO treatment are expected to be effective but must be proven by treatability testing as indicated by their lower criteria scoring. Excavation and off-site disposal was judged to be least desirable due to the increased soil handling and transport required.

Following consultation with Ecology, NWA will prepare a draft Cleanup Action Plan (CAP) describing the preferred remedial alternative in detail. This plan will include a rigorous evaluation of state and federal laws, which may apply to the cleanup action. In addition to the CAP, NWA will also develop a Compliance Monitoring Plan for the site to ensure continued compliance of the selected remedy with MTCA cleanup standards.

6.0 REFERENCES

(Note to readers: this list is incomplete.)

Adaska, Wayne S., Tkresouthick, and West. Solidification and Stabilization of Wastes Using Portland Cement. Portland Cement Association. 1991.

Conner, Jesse R. Chemical Fixation and Solidification of Hazardous Wastes. Van Nostrand Reinhold. 1990.

Gilliam, Michael T. and Wiles. Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes. ASTM Publication Code Number (PCN) 04-011230-56. 1992.

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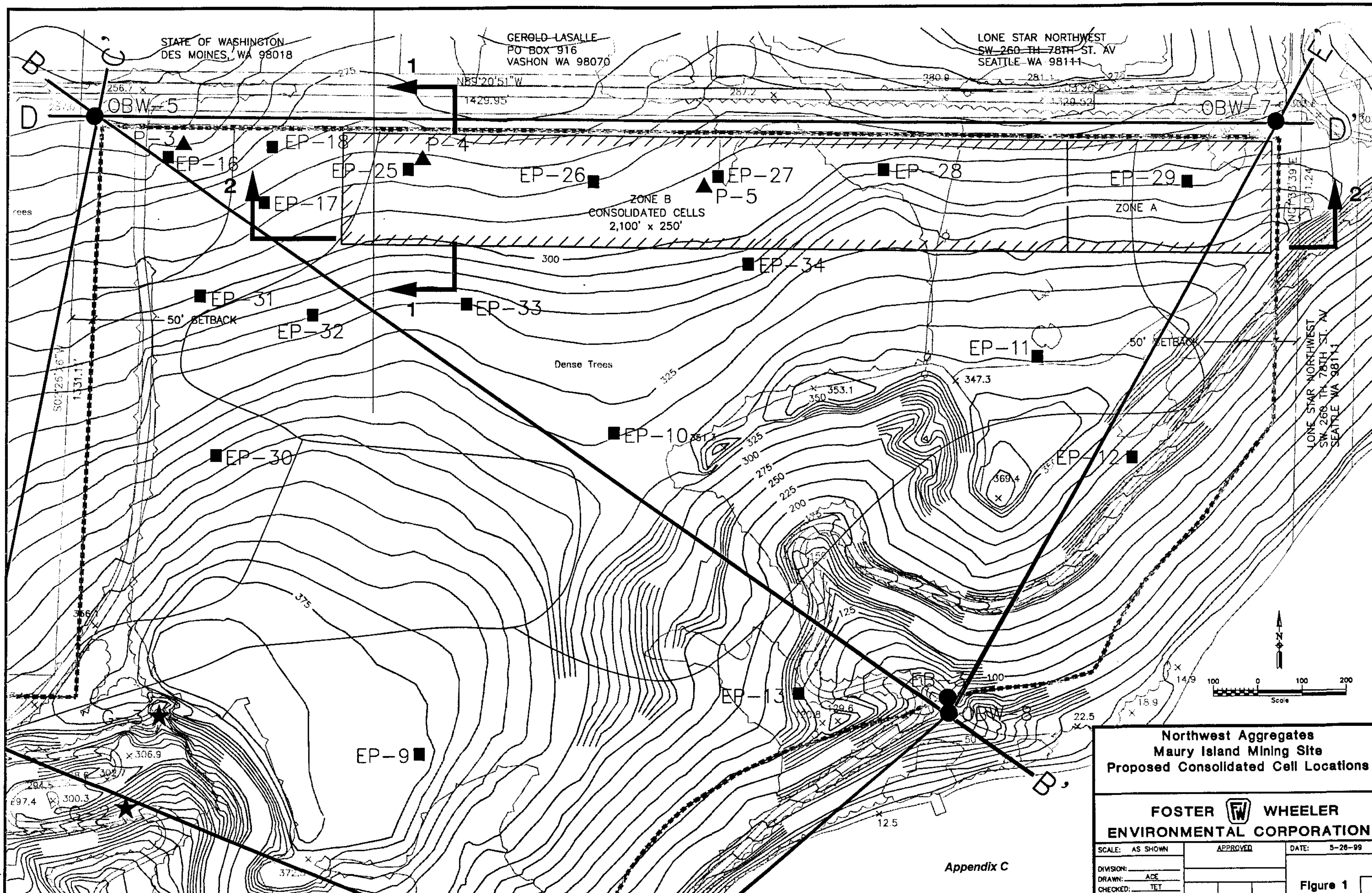
USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, EPA/540/G-89/004, October 1988.

Van Deuren, Julie, Wang and Ledbetter. Remediation Technologies Screening Matrix and Reference Guide, 3rd Edition. October 1997.

Wilk, Charles M. Waste Management Information, Stabilization of Heavy Metals with Portland Cement: Research Synopsis. Portland Cement Association. 1997.



Northwest Aggregates
Maury Island Mining Site
Proposed Consolidated Cell Locations

FOSTER WHEELER ENVIRONMENTAL CORPORATION

SCALE: AS SHOWN
APPROVED
DATE: 5-26-99
DIVISION:
DRAWN: ACE
CHECKED: TET

Appendix C

Figure 1

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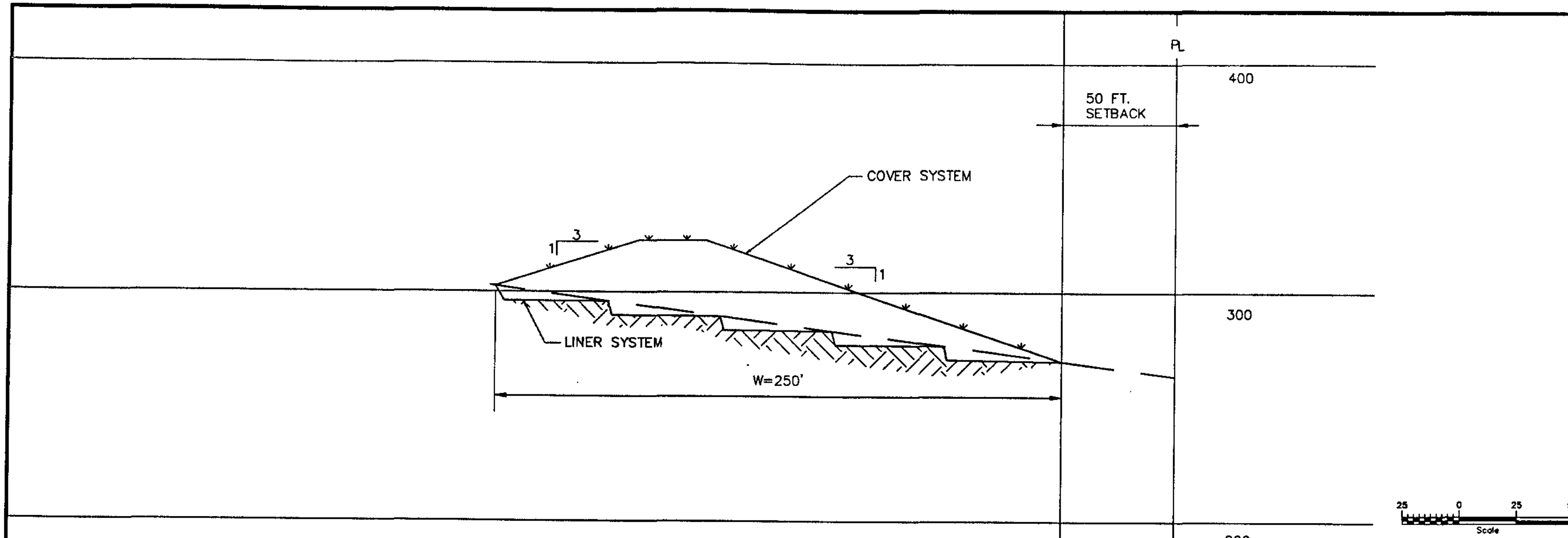
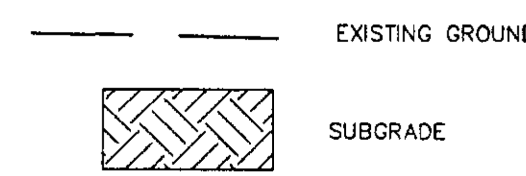
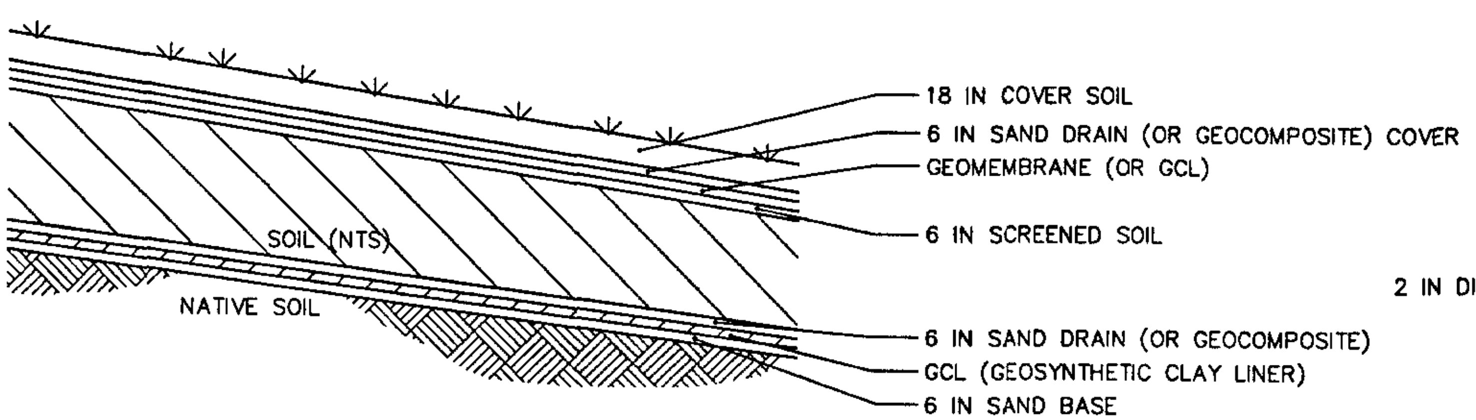


SECTION 1-1

LEGEND





LINER AND COVER SYSTEMS

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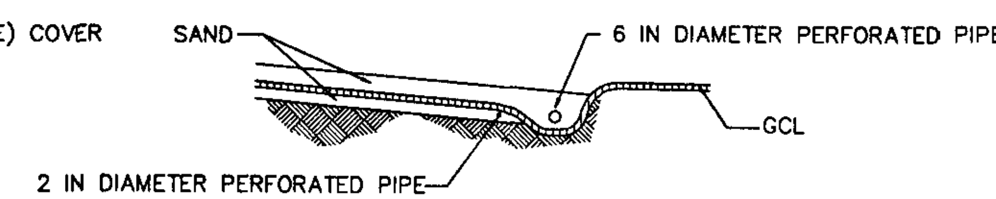

Appendix C

LEACHATE COLLECTION SYSTEM

N.T.S.

Aggregates Northwest
Maury Island Mining Site
SECTION 1-1
OF PROPOSED CONSOLIDATED CELL

FOSTER WHEELER
ENVIRONMENTAL CORPORATION

SCALE: AS SHOWN	APPROVED	DATE: 5-26-99
DIVISION:		
DRAWN: ACE		
CHECKED: TET		**Figure 2**

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